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DISEASES OF GREENHOUSE CUCUMBERS

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Due largely to the demand for vegetables out of season, the production of greenhouse cucumbers has become an important phase of the vegetable-growing industry in certain parts of Canada. In Ontario, the industry is largely concentrated in Essex County, and to a lesser degree in the Niagara Peninsula.

Being a "forced" crop, cucumbers are especially sensitive to the highly artificial conditions under which they are grown. As a result, it is seldom that a crop can be harvested without some loss being experienced from disease or other cause.

This bulletin describes various troubles encountered in forcing cucumbers, and suggests control measures which have proved successful in the culture of this crop.

FUNGOUS DISEASES

The fungi which cause diseases of cucumbers and many other plants are themselves plants of microscopic size. In their very smallness lies their chief danger. By means of air currents, insects, human beings, containers of various kinds, and many other agencies, they can enter a greenhouse entirely unknown to the grower, and, once having entered, can be further spread without his knowledge. In combating fungi and other parasitic organisms in the greenhouse, one of the first precautions must be to destroy those already present in the soil by thoroughly steaming it. If fungi or bacteria do gain entry by any of the means suggested above, affected plants should be eradicated and the remainder protected by spraying with a fungicide, where feasible. The burning of sulphur in the greenhouse just after the debris of the old crop is removed is good practice, as it destroys fungi and insects that would attack the succeeding crop. In some districts it is the practice to expose the greenhouses to the action of sun and air for a month or so after the crop has been harvested.

Damping-off

This is essentially a disease of seedlings while they are still in pots, though it sometimes causes most damage soon after the young plants are transplanted in the greenhouse. The disease may be due to one or other of several "damping-off" fungi, including species of *Pythium* and *Rhizoctonia,* which are frequently present in ordinary soil or even in steamed soil which has later become contaminated by admixture of manure or non-steamed soil. The disease is characterized by constriction, water-soaking, and discoloration of the stem at or near the ground level, followed by collapse and death of the young plants. Damage is usually most severe under conditions of low temperature, high moisture, and insufficient ventilation.

Control

1. Immediately before sowing, dust the seed with cuprous oxide (¼ teaspoonful of dust to 1 pound of seed). This treatment is in addition to the corrosive sublimate treatment which the seed should have already received for

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control of anthracnose and other diseases (see below). Some growers supplement the initial treatment by several later spray applications of cuprous oxide, according to manufacturer's directions, at 10-day intervals.

2. If an outbreak occurs, keep the plants as dry as possible and ventilate freely.

Anthracnose

Anthracnose is a fungous disease caused by *Colletotrichum lagenarium* (Pass.) Ell. and Halst. It attacks the leaves, stems, and fruit, producing on the former, brownish spots $\frac{1}{4}$ to $\frac{1}{2}$ inch or more in diameter (Fig. 1 C), and on the

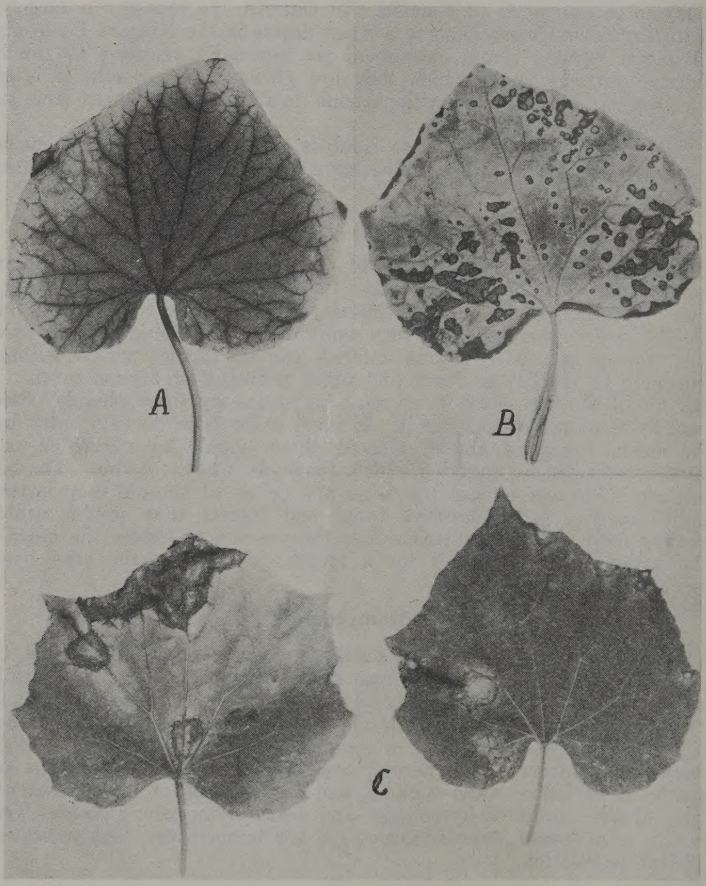


FIG. 1. Cucumber leaves manifesting symptoms of disease.
A. Potash deficiency. B. Angular leaf spot.
C. Anthracnose leaf spot.

latter, elongated, sunken areas. When infections are numerous on individual leaves, they usually die. High temperature and excessive humidity increase the severity of this disease. The fungus survives in the old diseased plant tissue in the soil of the greenhouse.

Control

1. Before sowing, place the seed in a cheesecloth bag, immerse for 5 minutes in a 1–1000 corrosive sublimate solution (mercuric chloride), rinse thoroughly in water and dry.
2. At the first sign of the disease, spray with a fixed copper such as cuprous oxide, or with bordeaux mixture 2-4-40, and repeat at weekly intervals.
3. In case of an outbreak do not use overhead irrigation, and be careful not to wet the leaves during watering operations.
4. Destroy all plant refuse after the crop is harvested.
5. Do not plant a second crop of cucumbers in a greenhouse where the disease has developed, unless the soil has been thoroughly sterilized.

Powdery Mildew

Powdery mildew, caused by the fungus *Erysiphe cichoracearum* D.C., is a common disease of cucumbers in greenhouses, especially towards the end of the season (May and June). It causes a white, powdery growth on the leaves and stems, and, eventually, affected leaves turn brown, dry out, and may finally die. In severe attacks the plant is weakened, the leaves turn yellowish, and the fruit remains immature.

Control

1. Provide adequate ventilation without subjecting the plants to excessive draughts, taking care to maintain uniform temperatures. Many growers believe greenhouse temperatures for cucumbers should be maintained at 65°F. to 70°F. during the night, and 75°F. to 85°F. during the day.
2. When the disease first appears, dust with sulphur, or spray with a fixed copper such as cuprous oxide, or with bordeaux mixture, 2-4-40, and repeat at weekly intervals.

Fusarium Wilt

This wilt disease, caused by a species of *Fusarium*, sometimes occurs on greenhouse cucumbers. It has been observed most frequently in older greenhouses and after the plants are in full production. Primary symptoms which consist of wilting of the growing tips, followed by yellowing and death of the entire plant, may be difficult to distinguish from symptoms of other troubles, particularly bacterial wilt and the wilting caused by nematodes. Often, however, the disease may be recognized by the brown discoloration of the internal conductive-tissues of the roots or of the lower part of the stem of affected plants. The fungus causing this disease lives from one season to the next in diseased crop refuse and soil. It is probable that it attacks other host plants as well as cucumbers.

Control

1. Remove and destroy all diseased plants.
2. Steam-sterilize affected greenhouse soil before planting another crop of cucumbers.

Stem Rot

This disease, caused by the fungus *Sclerotinia sclerotiorum* (Lib.) de Bary, usually appears in the greenhouse after the crop comes into production, but plants may be attacked at any stage of development. Primary symptoms consist of wilting and yellowing of the foliage, in some cases with accompanying white

cottony growth of the fungus at the nodes of the main stem or on developing fruits. The presence of this white cottony growth in which are often embedded small, black bodies known as sclerotia, helps to distinguish stem rot from other wilt-producing diseases. The hard, thick-walled sclerotia are the means by which the fungus is perpetuated in the soil. In later stages of the disease, the main stem rots at the ground level or at infected nodes. Stem portions above and below affected areas are held together by strands of more-resistant tissues. Mature fruits, apparently healthy but with infections still invisible to the unaided eye, rapidly develop a watery, soft rot in transit or in storage.

Control

1. Sterilize greenhouse soil with steam.
2. Remove and destroy all plant debris in affected greenhouses.

Scab

Scab which occasionally attacks greenhouse cucumbers is caused by the fungus *Cladosporium cucumerinum* E. and A. The disease is also referred to as "gummosis" or "the weeps", because of the symptoms produced on the fruit. Small sunken spots appear on the fruit followed by an amber-coloured ooze secreted from the affected area. After this has dried, the fungus itself forms a greyish mould over the spot and produces spores. The disease may also cause a leaf spot. Scab is always associated with very humid conditions and is seldom encountered when the ventilation is adequate.

Control

1. Where this disease is persistently troublesome, additional ventilation should be provided to reduce the humidity. In wet weather it may be necessary to raise the temperature in the houses.
2. Sulphur fungicides will effect a partial control. Sulphur dust, or a micro-fine wettable sulphur spray used according to manufacturer's directions, may be applied.

BACTERIAL DISEASES

Bacteria which cause plant diseases are microscopic in size and even smaller than fungi. It would require 25,000 individual bacteria laid end to end to make one inch in length. Under favourable conditions bacterial diseases are often more destructive than those caused by fungi. Generally speaking, the control of bacterial diseases requires precautions similar to those practised for fungous diseases.

Bacterial Wilt

This wilt disease, caused by *Erwinia tracheiphila* (E.F.S.) Bergey *et al.*, sometimes affects greenhouse cucumbers. The disease is characterized by a wilting of the foliage due to the presence of large numbers of bacteria in the water-conducting vessels of the stem. Wilting of the extreme tips of the branches is soon followed by the wilting and death of the entire plant. The disease may generally be recognized by white, sticky masses of bacteria which ooze from the cut ends of affected stems, particularly if the latter are squeezed. Results of investigations to date indicate that the bacteria are carried in the bodies of the striped and 12-spotted cucumber beetles. Contaminated beetles gaining entrance to greenhouses in the fall would inoculate plants when feeding on them. It is possible that other insects may also spread the disease.

Control

1. Remove and destroy wilted plants immediately.

Control beetles in the greenhouse by screening the ventilators or by fumigation.

Angular Leaf Spot

This is a bacterial disease caused by *Phytomonas lachrymans* (Smith and Bryan) Bergey et al. Though often a widespread and serious disease of cucumbers in the field, it is only occasionally present in the greenhouse crop. It is recognized by the small, angular spots on the leaves, at first dark green, and later tan in colour (Fig. 1, B). Both flowers and fruit are sometimes affected in the field, but no infection of these parts has been observed in the greenhouse. The bacteria overwinter on infected seed and in the soil, and are spread by means of insects and workers.

Control

Same as for anthracnose.

VIRUS DISEASES

This highly-important group of plant diseases is caused by an infectious agent smaller even than either fungi or bacteria, and resident in the sap of affected plants. The causal agent is spread by transfer of juice by insects or man from diseased to healthy plants. Virus diseases are often so highly contagious that it is only necessary to brush against a diseased plant and then a healthy one to transmit the disease to the latter.

Mosaic

Mosaic is one of the most serious diseases of greenhouse cucumbers. Symptoms first appear as mottling, yellowing, and sometimes curling of the leaves (Fig. 2). If infection occurs before the plant reaches the production stage, shortening of the internodes results in stunting of the entire plant. The fruit on affected plants is mottled, malformed, and often warty in appearance (Fig. 3). Affected plants usually wither and die within 14 to 20 days after the first symptoms appear.

FIG. 2. Leaf of greenhouse cucumber showing mottle symptom of mosaic.

This disease is spread by the transfer of juice from infected to healthy plants. Spread is often quite rapid, principal agents of transfer being insects such as cucumber beetles and aphides. The disease may also be spread by workers during cultural operations, such as pruning and picking.

Typical cucumber mosaic may also attack celery, spinach, tobacco, and pepper. Plants in which this virus may overwinter include the wild ground-cherry (*Physalis subglabrata*, Mack. and Bush and *P. heterophylla* Nees), pokeweed (*Phytolacca decandra* L.), milkweed (*Asclepias syriaca* L.),

catnip (*Nepeta cataria* L.), and probably other susceptible perennials. Seed transmission has been reported in the wild cucumber (*Echinocystis lobata* (Michx) Torr. and Gray), but rarely, if ever, does this occur in the cultivated species.

FIG. 3. Greenhouse cucumber affected with mosaic.

Control

1. Remove all weeds in the vicinity of the greenhouses, especially wild cucumber, milkweed, ground-cherry, catnip, and pokeweed. If possible, practise clean cultivation adjacent to the greenhouses.

2. Practise regular fumigation or spraying in the greenhouse to control insects which spread the disease.

3. Cut diseased plants at base of stem, *allow to dry out, and then remove and destroy.* If this procedure is carefully followed, danger of spread to adjacent healthy plants is reduced, since mosaic plants lose their infective capacity when dried.

4. If the disease becomes widespread before it is recognized, it may be preferable not to remove affected plants, but rather to salvage as much marketable fruit as possible from both diseased and healthy plants.

NEMATODES

Nematodes are minute, worm-like organisms which attack many different plants. The species which attacks cucumber (*Heterodera marioni* (Cornu) Goodey), flourishes at the high temperature that generally prevails in the light, sandy soil in which greenhouse cucumbers are commonly grown. Consequently, the problem of nematode control has become one of the most important in the production of this crop.

Above-ground symptoms of affected plants are stunting, yellowing, and retarded growth, followed by wilting of leaves, reduction in development of mature fruit and eventually death. Underground symptoms, which are unmistakable, consist of knobby galls or enlargements on the root system. The galls may appear as small, scattered, tubercle-like growths, or as extensive, elongated swellings up to one inch or more in diameter (Fig. 4). The duration and intensity of symptom expression depend on the age of the plant attacked and on the number of nematodes involved. If the latter are numerous, the galls may be correspondingly numerous and large. They develop as the result of the invasion of the root tissues by the tiny eel-worms.

FIG. 4. Root system of greenhouse cucumbers showing galls due to nematodes.

Eggs of this nematode are about $\frac{1}{250}$ inch long and are produced by the female within the affected roots. It is reported that a complete life cycle requires 3 weeks to 2 months, and many generations are produced in a year. The root-knot nematode is sensitive to cold or heat, drought or moisture, and certain chemicals.

A favourable soil temperature is chiefly responsible for the multiplication of *H. marioni* in the soil. As exemplifying the sensitivity of this nematode to soil temperature, it may be pointed out that lettuce can be grown in nematode-infested soil at 45° to 60° F. with very little damage, while cucumbers or tomatoes grown at 70° to 75° F. in similarly infested soil become severely affected. Because the relatively high soil temperature and moisture at which greenhouse cucumbers are grown also favour the root-knot nematode, the latter almost always becomes a problem of importance in the culture of this crop. Unfortunately, it is impossible to manipulate either soil temperature or soil moisture to the disadvantage of the nematode without also injuring the crop. However, the practice of some growers in Ontario of allowing infested greenhouse soil to dry out thoroughly in the summer, and to undergo a period of freezing in the winter, is not to be discouraged, since under such conditions populations of the nematode may be materially reduced. This practice, however, must not be relied upon as a substitute for steaming the soil. The root-knot nematode also attacks a large number of different plants, including both wild and cultivated species.

Control

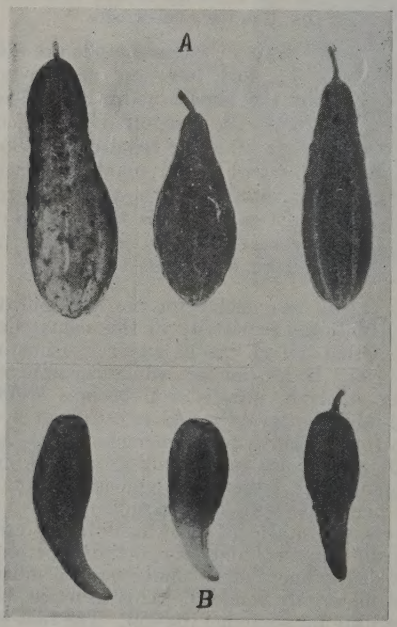
1. Remove and destroy affected plants.
2. Replace or sterilize the greenhouse soil, preferably with steam. Owing to the fact that this nematode has frequently been found at a depth of 24 inches or more, it is necessary that the sterilization be very thorough. To ensure control around posts and inside walls of greenhouses, where infestations have occurred and where thorough steaming is difficult, it is good practice to wet these areas by applying formalin (1 part commercial formalin to 20 parts water) with a sprinkling can or sprayer.

PHYSIOLOGICAL DISEASES

There is another important group of diseases of greenhouse cucumbers that cannot be attributed to the attack of parasites of any kind, but are due rather to lack of balance or deficiency of nutrient materials. Troubles arising from such causes are termed physiological diseases.

Nitrogen Deficiency

A deficiency of nitrogen may become acute for greenhouse cucumbers at any stage of their development. While this condition has only rarely been observed on seedlings, it is quite common for symptoms to develop after the plants are in full production. At this time, symptoms appear quite suddenly, the earliest of which consist of stunting of the plant followed by a fading of the normal green colour through various shades of greenish yellow to a pale lemon yellow. Usually symptoms appear first on the youngest leaves and then progress down the stem towards the older ones.



Under conditions of continued nitrogen deficiency, leaves of affected plants remain smaller and thinner than those of normal plants. Also, stems of affected plants remain slender and become hard and fibrous. Roots do not appear to be inhibited in growth and proportionately are more fully developed than above-ground parts. Fruit formation is restricted both as to number and size, and in extreme cases flowers and flower buds drop off. Probably the most characteristic symptom of nitrogen deficiency on the producing crop, and one by which it can be readily identified, is the light colour of the fruit accompanied by malformation due to tapering of the blossom end (Fig. 5, B).

FIG. 5. Greenhouse cucumbers showing deficiency symptoms.
A. Potash deficient. Note tapering at stem end.
B. Nitrogen deficient. Note tapering at blossom end.

Control

Make suitable applications of nitrogen employing a complete fertilizer, nitrate of soda, or well-rotted manure. Response from applications of nitrate of soda become apparent within 3 to 4 days, though use of this material is dangerous, and will injure the roots, if excessive amounts are used, or if the roots are not well covered with soil.

Phosphorus Deficiency

It is not unusual for symptoms of phosphorus deficiency to appear in greenhouse cucumber crops. Under such a condition, growth is retarded and maturity is delayed. In the early stages of phosphorus deficiency, the plants become abnormally dark green in colour and the leaves lack their normal lustre. Stems of phosphorus deficient cucumbers are often abnormally slender and fibrous. Roots almost invariably become noticeably stunted through lack of normal development. Fruits sometimes become bronzed in appearance, always seem to lack their usual lustre, and mature slowly.

Control

Make suitable applications of superphosphate or a complete fertilizer.

Potash Deficiency

In greenhouses, potash deficiency frequently manifests itself after the cucumber plants come into production, though characteristic symptoms of this trouble may develop at any stage of growth. Potash-deficient cucumber plants grow slowly, assume an ashy, grey-green colour, and produce low yields. Often the first symptom noticed by the grower is a light, yellowish-green margin on the older leaves (Fig. 1, A). Such discoloured margins may or may not turn brown and die. Young leaves of affected plants may be crinkled like crêpe paper. Potash is only loosely combined in plant tissues and may readily be translocated within the plant. In the cucumber, such translocation often takes place from older to younger leaves. The former then show the symptoms described above, while the latter appear perfectly healthy. Stems of potash-deficient plants become hard, woody, and slender, and petioles and veins of leaves on such plants are brittle and break off with slight, upward pressure. Roots of affected plants are slender, poorly developed, and often discoloured.

An outstanding symptom of potash deficiency in cucumbers is the effect on the fruit which, failing to develop at the stem end, tends to become gour-shaped (Fig. 5, A). The tissues of the narrower stem-end of such fruits are tough and usually almost tasteless.

Control

Make suitable applications of potash, preferably muriate of potash, or a complete fertilizer high in potash. It should be noted that when additional nitrogen is applied to a crop where potash is limited, often the resulting increased growth hastens the appearance of symptoms of potash deficiency.

"FERTILIZER BURN"

Being a "forced" crop, greenhouse cucumbers are given an abundance of fertilizer, not only to bring them into early production, but also to maintain production at a high level. This practice which involves more or less frequent applications of both commercial fertilizer and manure, often results in damage to the plant. The application of large amounts of raw, undecomposed manure, or manure mixed with materials such as shavings or sawdust, is probably the most frequent cause of fertilizer burn in greenhouses.

Above-ground symptoms consist first of wilting, followed by the death of the tissues between the leaf veins, and often of the margins as well. Lower leaves, which are the first affected, usually assume a dark green colour. Underground symptoms consist of discoloration and death of the finer rootlets.

Control

1. Avoid the use of excessive amounts of commercial fertilizer, particularly nitrate of soda or potash.

2. Use only well-rotted manure free from injurious materials. Experience has shown that mixtures containing high proportions of hog manure are dangerous at any stage of plant development, and applications of sheep manure are highly dangerous to seedlings.

3. Before applying commercial fertilizer to cucumber plants with exposed roots, the latter should first be covered lightly with either well-rotted manure or a mixture of manure and sterilized soil.

CONDITIONS RESULTING FROM FAULTY CULTURAL PRACTICES

Effects of Chilling

Wilting may result from a sudden chill or draught. Usually, this form of wilt is more frequent early in the season when ventilators are opened for the first few times, and before the plants have established extensive root systems. Often at this stage of development only a slight draught or a sudden drop in temperature will result in temporary but exaggerated symptoms of wilt.

Effects of High Temperature

Temporary wilting may also occur when the temperature in the greenhouse rises above 90° F., as sometimes happens early in the season when it is dangerous to ventilate freely because of chilling draughts. Prolonged high temperature, accompanied by bright sunshine, may finally result in the death of the margin of the leaves on the lower portion of the plant.

Effects of Improper Watering

Injuries due to improper watering of greenhouse cucumbers are quite common. Excessive watering of plants for a period following transplanting, or on cold, dull days, often causes serious harm. Under such conditions, wilting develops, and this is followed by retarded growth, yellowing, and sometimes injury to the root system. Every grower should study his own soil in this respect. Experience has shown that during February and March, special caution in watering should be exercised, because drainage is less perfect at this time than later. It has also been observed that most difficulty in this respect is experienced in greenhouses which are not tiled for steaming purposes, and where the insulating effect of excess quantities of poor quality manure maintains the underlying soil at below optimum temperatures.

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